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CLASSIFICATION AND ASSIGNMENT WITHIN PRIDE (CLASP): A RECRUIT ASSIGNMENT MODEL

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CLASSIFICATION AND ASSIGNMENT WITHIN PRIDE (CLASP): A RECRUIT ASSIGNMENT MODEL

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The purpose of this research was to design, construct, and test a mathematical model for optimal assignment of Navy recruit applicants. Navy policy data were used to formulate experimental forms of utility model components. The forms were tested in a simulation procedure using Navy accession data. Performance characteristics were evaluated for the model, called Classification and Assignment Within PRIDE (CLASP). Results showed that the CLASP personnel allocation system provides decision-makers

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with an improved tool for personnel classification and placement. It enables managers to make personnel decisions with both greater accuracy and greater concern for individual applicants. Under both field test and simulation conditions, the CLASP procedure assigned personnel more effectively to optimal ratings than did the existing first-come, first-served procedure.

FOREWORD

The purpose of this research, which was conducted under project Z1167-PN.02 (Computer-Assisted Testing, Counseling, and Assignment of Recruits), was to develop and test a computerized system for Navy personnel assignment. This system, called Classification and Assignment Within PRIDE (CLASP), was implemented by the Commander, Navy Recruiting Command (CNRC) on 2 June 1981. Since then, it has been used to assign recruit applicants to ratings requiring "A" school training. This report documents the CLASP model's development and initial evaluation. Research results are intended for program managers at the Navy Military Personnel Command (NMPC-48), CNRC-20, and CNRC-30, as well as Department of Defense researchers involved in developing personnel allocation systems.

Appreciation is expressed to CAPT Jensen (NMPC-48), CAPT Terrell (CNRC-20), LCDR Biegler (NMPC-481), and LCDR Sheehan (NMPC-482) for their significant contributions to policy modeling and to assignment system development and testing. In addition, many useful recommendations were contributed by NMPC and CNRC headquarters and field personnel. The final version of the CLASP system contained many of the recommended improvements.

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SUMMARY

Problem

Since 1973, recruit applicants have been assigned to "A" school seats on a first-come, first-served basis with the aid of a computerized reservation network called Personalized Recruiting for Immediate and Delayed Enlistment (PRIDE). A new assignment procedure was needed that could apply a consistent decision-oriented classification rationale to each prospective applicant, use more information about each applicant's job preferences, and operate on all Navy jobs available nationwide.

Purpose

The purpose of the research reported here was to design, construct, and test a mathematical model for optimal assignment of recruit applicants.

Approach

Navy policy data were used to formulate experimental forms for utility model components. Each experimental form was tested in a simulation procedure using Navy accession data. Performance characteristics were noted, revisions made, and refined functional forms were derived for the composite model, called Classification and Assignment Within PRIDE (CLASP). Results from a simulation of the CLASP composite model were evaluated and compared to PRIDE assignments and to data from a 1978 CLASP field test for their capacity to (1) maximize training school success, (2) optimize matching of aptitude level and Navy job complexity, (3) optimize matching of applicant preferences and Navy requirements, (4) fill quotas at uniform rates within all Navy ratings, and (5) balance the distribution of ethnic minorities within all ratings.

Results

Both the simulation and the field test confirmed the capability of CLASP to make optimal assignments of recruit applicants:

1. The CLASP procedure yielded assignments higher in quality than those obtained under the PRIDE process when compared on the basis of optimality index scores and mean square statistics.

2. Comparison between overall CLASP assignment quality and the proportion of vacancies in the job bank showed that quality was highest when there were large numbers of vacancies and lower when few positions remained to be filled.

3. The CLASP procedure was more effective than the PRIDE process at filling rating quotas uniformly and distributing the proportion of minority recruits evenly across the 86 ratings included in the research.

The CLASP system was implemented by the Navy Recruiting Command on 2 June 1981.

Conclusions

CLASP provides decision-makers with an improved tool for personnel classification and placement. It enables managers to make personnel decisions with both greater

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accuracy and greater concern for individual applicants. Under field test as well as simulation conditions, the CLASP optimal-sequential assignment procedure assigned personnel more effectively to optimal ratings than did the PRIDE first-come, first served procedure. In addition, CLASP minority ratios more closely approximated specified target ratios, and "A" school seat allocation proceeded at a more uniform rate under all conditions tested. Other personal and system benefits, such as improved job satisfaction, morale, and reenlistment rates, are also expected but could not be supported by data collected in this research.

This study was not designed to collect data to answer questions about attrition. However, the results indicated that improved matching between persons and jobs, as accomplished by CLASP, may be a significant factor in the ultimate reduction of attrition and attrition cost.

Recommendations

It is recommended that the Naval Military Personnel Command (NMPC-48):

1. Monitor CLASP to assess the performance of both the assignment system and the recruiters and classifiers who use it. Multivariate approaches that incorporate more behavioral aspects of the career decision process would be examined by the Navy Personnel Research and Development Center (NAVPERSRANDCEN).

2. Continue its ongoing efforts to use CLASP as a vehicle for assessing the quality of Navy person-job matches.

3. Evaluate the requirement for extending the model to encompass more components and to assign additional groups. An attrition component presently under development would be evaluated for inclusion. The model would be extended to include women, a change that will require development of new criteria and school success prediction equations.

It is recommended that NAVPERSRANDCEN (1) monitor the model's operating characteristics under a variety of conditions, and (2) conduct a sensitivity study to ascertain the degree of stability of solutions generated under the optimal-sequential procedure.

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INTRODUCTION

One of the final steps in the military accessioning process occurs at regional military enlistment processing stations (MEPSs) (formerly called armed forces examining and entrance stations (AFEESs)). The MEPSs, which serve all the military services, evaluate potential recruits mentally and physically to ascertain their suitability for service. Once basic qualification is determined, the process of determining technical school ("A" school) assignment begins.

From 1973 until 1981, recruit applicants were assigned to Navy jobs or ratings on a first-come, first-served basis, using a computerized reservation network adapted from the Army's REQUEST system and named Personalized Recruitment for Immediate and Delayed Enlistment (PRIDE). When these assignment decisions were examined closely, it was shown that they frequently (1) could not distinguish assignment options on the basis of predicted school success, (2) neglected matching personnel of a given ability level with jobs appropriate for that level, (3) lacked response flexibility to changing Navy priorities, (4) could not incorporate applicants' preferences in a consistent way, (5) failed to accommodate important Navy objectives such as uniform minority and "A" school accession rate, (6) reflected rating availability instead of assignment quality, and (7) neglected applicant quality in favor of satisfying recruiting goal requirements. A new assignment procedure was needed that could apply a consistent decision-oriented classification rationale to each prospective applicant, use more information about each applicant's job preference, and operate on all Navy jobs available nationwide.

Background

During the past 20 years, the technology and process for assigning Navy enlistees to job training have changed dramatically. Until the 1960s, classifiers at the three recruit training centers (RTCs) hand-sorted stacks of cards that represented a week's recruit pool into pigeonholes that represented available assignments. After 1965, these classifiers had the assistance of the computer-assisted classification system (COMPASS), which incorporated mathematical optimizing techniques and the computer's speed to improve the quality of assignment decisions (Dow, Wolfe, Moonan, Swanson, & Taylor, 1964; Swanson & Dow, 1965). In 1973, the assignment process shifted to the AFEESs (now called MEPSs). After making assignment decisions, Navy classifiers reserved places for technical training in "A" schools by using the PRIDE computerized reservation network.

Strategies for improving the quality of job training assignments developed as consequences of the political, economic, and social changes that impinged on the military services. With the end of conscription in 1973, there was a shift in proportions of enlistees: Fewer came from the higher mental ability groups and more from the lower groups. At the same time, the overall trend in the United States toward use of increasingly sophisticated machines and, thus, greater need for technically skilled workers, has been paralleled by the Navy's increasing need for technically skilled personnel to operate and maintain sophisticated military equipment. Under today's all-volunteer force (AVF), training guarantees are often offered as incentives for military enlistment. Quotas for technical training schools must be filled seque ally, at whatever time enlistees present themselves, without knowing whether the next applicant might be better qualified for a job than the person just assigned to it. Refined, improved assignment strategies have been developed to make optimal use of the available applicants, to improve their Navy job success, and, therefore, to reduce attrition with its associated retraining and replacement costs.

Sequential Assignment

The early research dealing with aspects of the assignment question focused on attempts to develop optimal allocation algorithms to handle pooled personnel available all at one time. Brogden (1946) first addressed the problem of optimal assignment with more than two job categories. Votaw (1952) and Dwyer (1954) recognized the equivalence between optimal personnel assignment and the linear programming transportation problem. They proposed using the simplex and optimal regions methods.

However, under current conditions, a functional Navy accessioning system requires that personnel be assigned as they become available. Research in sequential assignment was conducted by Horst and Sorenson (1976), who proposed a matrix transformation method that resulted in near-optimal assignments. Rafacz and Halstead (1977) developed a method to allow comparisons between present and possible future applicants. They used a matching function to estimate optimal assignments that depend on a shadow population resembling the real one to which the present applicant belongs.

Assignment Quality

The shift from pooled assignment at three RTCs to sequential assignment at many MEPSs developed from attempts to bring assignments into close correspondence with recruits' individual needs and preferences. This approach resulted in approximately 60 percent of recruits destined for "A" schools being assigned by MEPS classifiers, using the PRIDE computer reservation network. The remaining 40 percent were sent to RTCs and assigned later by the COMPASS II model (Hatch, Pierce, & Fischer, 1968). COMPASS II used an efficient procedure developed by Hatch (1971, 1975) and based on the network flow algorithms of Ford and Fulkerson (1962).

During a typical recruit interview at a MEPS, the classifier compared training school quotas to each recruit's physical data, Armed Services Vocational Aptitude Battery (ASVAB) scores, desired entry dates, and job preferences. A short discussion was held with the applicant before agreement was reached on a rating assignment. Using PRIDE, the classifier established the availability of the desired rating and entered the reservation for a school seat. While PRIDE required the classifier to make a judgment about the best Navy job for each applicant, most classifiers possessed a high level of expertise with respect to only a few Navy ratings--not to all. The inconsistency of this assignment process was exacerbated by the short time available for interviewing each applicant.

The limitations of the assignment process prompted the Navy Recruiting Command (NRC) and the Bureau of Naval Personnel to seek assistance from the Navy Personnel Research and Development Center (NAVPERSRANDCEN) in developing a comprehensive classification procedure for nonprior-service males that would incorporate an optimal-sequential algorithm similar to the one used by the Air Force Advanced Personnel Data System's Procurement Management Information System (APDS-PROMIS) (Ward, Haney, Hendrix, & Pina, 1978). A flexible assignment process was required that would provide tradeoffs between conflicting objectives and retain the advantages of APDS-PROMIS while operating within the PRIDE computer system and exhibiting characteristics uniquely suited to the Navy.

It appeared that a mathematical model that would produce optimal assignment of applicants as they become available offered significant potential benefits. This approach could be employed to model and quantify conflicting objectives and could subsequently be used to define the criterion to which an optimization procedure would be applied. The

assignment system proposed for development by NAVPERSRANDCEN was entitled Classification and Assignment Within PRIDE (CLASP).

The CLASP model incorporates results from earlier research. An index of prediction efficiency was developed by Horst (1954) in his attempts to produce methodologies for constructing differential prediction test batteries. The decision index procedure, the basis of the optimal-sequential assignment approach in APDS-PROMIS and CLASP, was first proposed by Ward (1959) in his attempt to obtain close-to-optimal solutions under sequential assignment conditions. Ward noted that the size of the analysis of variance interaction term describing the person-job matrix was directly related to the Horst index. The significance of this observation lies in the fact that military personnel managers may devise policies that affect differential classification through the linking mechanism of the interaction term. In other words, the effectiveness of the differential assignment procedure can be influenced by the manipulation of policy variables. McWilliams (1970) showed that the decision index was remarkably effective in developing approximate solutions to the transportation problem, when compared to various alternatives.

Objectives

The objectives of the effort reported here were to (1) design and construct a utility model for optimal assignment of male recruit applicants and describe the weighting problem that determined composite utility scores, (2) test the utility model in a simulated optimal-sequential assignment, and (3) compare the simulation results of the new optimal-sequential assignment procedure with typical results from the PRIDE first-come, first-served procedure.

APPROACH

The set of dimensions used by a person to evaluate a prospective job will often be different from the set used by an organization to evaluate an applicant. The whole set of individual and organizational dimensions may be considered as a common space characteristic of a particular person-job match. Clearly, any given match involves compromise in a number of the dimensions by both the applicant and the organization.

Preliminary discussion with NRC personnel identified several critical factors for developing the CLASP person-job matching system:

1. CLASP should consist of a utility model, designed in modules to facilitate integrating components and implementing the model.

2. The model should use an algorithm similar to the one used by the Air Force APDS-PROMIS system.

3. The CLASP system should be compatible with the goaling procedures currently used by NRC.

4. The CLASP system should work compatibly with the PRIDE computerized reservation system.

5. CLASP operating procedures should require no additional classification time at MEPS.

CLASP Utility Model Development

The Air Force APDS-PROMIS system was investigated and it was decided that a number of design concepts could be adapted for use in a Navy system. Discussions with Navy manpower and personnel decision makers resulted in guidelines to be followed in developing model components. Subsequently, functional forms of several CLASP model components were derived from Navy policy data, using a policy-capturing program developed by Ward (1977). The CLASP mathematical model was designed to provide Navy rating (job) options to first-term, nonprior service male applicants at the MEPSs. It incorporates Navy policy as well as data on the the applicants' abilities and preferences to achieve (1) maximum training school success, (2) optimal matching of aptitude level and job complexity, (3) optimal matching of applicant preferences and Navy requirements, (4) orderly fill rates within all Navy jobs (ratings), and (5) balanced minority fill rates within all ratings.

After preliminary policy data were gathered for each component and a tentative functional form produced for each, the functional forms were tested in a simulation procedure using data from actual Navy accessions. The performance characteristics were noted, revisions made, and refined functional forms were derived. The result was a utility model that could be used to approximate a procedure for optimal person-job matching and that could be evaluated on a larger scale.

CLASP Model Evaluation

To test the quality of the CLASP model's person-job matching on a large scale, a computer simulation of Navy "A" school assignments was designed. The simulation compared the actual assignments made by classifiers using the PRIDE reservation network to hypothetical CLASP assignments of the same recruits.

Sample

NRC prepared and sent to NAVPERSRANDCEN tapes containing data for all recruits who entered the Navy during July 1977. Out of that month's total of 11,202 recruits, 3,516 were assigned to "A" school seats by classifiers using the PRIDE first-come, first-served procedure; and the rest, to school seats or fleet billets during recruit training. The 3,516 recruits assigned to "A" school by classifiers, some of whom had been recruited during the preceding 9 months as part of a delayed-entry program, were the target population for this research.

PRIDE Assignments

The Navy classifiers assigned the majority of the 3,516 recruits to school seats for specific ratings; the others were assigned to occupational specialties (OCCSPEC), broad occupational groupings comprised of many different ratings. Because the CLASP procedure requires quotas specified by rating, the number of OCCSPEC school seats was subdivided into the appropriate numbers of specific school seats.

For simulation purposes, a random assignment algorithm was used to place each recruit from an OCCSPEC category into one of the specific school seat categories. This process continued until all recruits in the OCCSPEC groupings were assigned to specific school seats in 86 ratings (listed in Appendix A).

CLASP Assignments

CLASP requires that a classifier obtain recruit applicant information concerning (1) ASVAB test scores, (2) job preferences, (3) minority group membership, (4) physical qualifications, (5) citizenship, and (6) high school graduation. The first three kinds of information are used directly to determine rating options for each applicant; and the rest, to restrict the list to ratings for which the applicant meets the requirements.

Except for job preferences, all this information was available on the NRC data tapes. Job preference data to be used in the simulation exercise were obtained indirectly, by identifying the job area containing the rating to which a recruit had been assigned under the PRIDE procedure, and then specifying that this job area carry the largest value (100) on the preference scale. Since the recruits' other choices were unknown, lower preference scale values were randomly assigned to remaining job areas for each person. This process evaluated CLASP assignments by their degree of correspondence to PRIDE assignments, but its introduction of randomization placed the CLASP assignment procedure at a disadvantage to PRIDE. Thus, the quality of the CLASP solution was lower than it would have been under free-choice operating conditions.

The recruit data were entered into the optimal-sequential computer program, which produced rating option lists for each recruit in the same order that their PRIDE reservations had been recorded in the NRC data base. The CLASP assignment was defined as the uppermost rating option on each person's list.

Field Test

In 1978, CLASP was field-tested at eight MEPSs in cities across the United States. Navy classifiers used CLASP to assign a total of 341 recruit applicants to "A" school training. The assignments were evaluated for their overall quality (optimality) and correspondence to applicant preferences.

RESULTS AND DISCUSSION

CLASP Utility Model Development

The CLASP utility model was formulated to ensure consistent application of Navy policies among classifiers and from one assignment to the next. It is comprised of five utility-generating components: (1) school success, (2) technical aptitude/job complexity, (3) Navy priority/individual preference, (4) minority fill-rate, and (5) fraction fill-rate. Each component was designed to influence the assignment procedure independently of the others. This design does not imply strict statistical independence; rather, a slight degree of correlation among the utility components was expected.

The CLASP classification procedure operates on a payoff matrix, a rectangular array of numbers representing the utilities of the various decision outcome combinations. The utilities express the value to the Navy (on an arbitrary scale) of the consequences of assigning a specific person to a specific job. The higher payoff values are more desirable than the lower ones, because the probability of a person succeeding in a job is a monotonically increasing function of increasing payoff value.

The utility of assigning a particular person to a particular job is derived from a weighted linear combination of utilities, with each component expressing a different

aspect of the decision outcome. The whole utility model is a first approximation to matching persons and jobs, taking into account the behavior and judgment of both recruit applicants and Navy classifiers. The five components are described in the following paragraphs.

School Success Component

The school success component predicts success as a function of ASVAB subtest scores. Before CLASP, classifiers made "A" school assignments based on the cutoff score for a rating, without considering the degree to which an applicant might exceed that score. Because an applicant's potential for school success increases as his or her aptitude scores rise, the CLASP school success component was designed to incorporate information about the full range of aptitude scores, instead of being limited to cutoff scores. Different combinations of subtest scores are used to predict school success for each rating.

School success is measured by final "A" school performance grade. It is employed as the criterion variable in a linear regression involving ASVAB subtest scores as predictor variables. For each of the 86 Navy ratings used in this research, a regression equation was obtained that produced the maximum multiple correlation between the criterion and the predictors. The unique linear combination of predictor variables (ASVAB subtest scores) for a given rating defines a composite score value when applied to a given individual. In fact, X_{ij}, the composite score for person _i_ and rating _j_, could be used to order persons according to the degree of success expected during "A" school training in preparation for tasks in the _j_'th rating.

The school success component yields a numerical value for relative utility as a function of X_{ij}, $\bar{X}_{\cdot j}$ (the average composite score for the _j_'th rating), and σ_j (the standard deviation (SD) of the distribution of X_{ij} scores for the _j_'th rating). The utility equation for the _j_'th rating is given by:

$$U_{ij} = mP + Q \frac{(X_{ij} - \bar{X}_{\cdot j})}{\sigma_j} \qquad (1)$$

where:

U_{ij} is the school success utility value associated with placing person i in rating j,

m, P, and Q are scaling constants, and

X_{ij}, $\bar{X}_{\cdot j}$, and σ_j are as defined above.

Given appropriate choices of the scaling constants, the U_{ij} scores could be expressed in the same metric. This procedure facilitates comparing ratings for person _i_ and allows the rating for which U_{ij} is largest to be identified as the optimal rating with respect to school success for person _i_. In all, 86 school success utility equations were developed, one for each rating.

Technical Aptitude/Job Complexity Component

In ascertaining whether an applicant is suited to a particular job, an employer must assess the job's requirements and the applicant's abilities. In other words, the employer must decide whether a particular person has the abilities required for success in a particular job.

During a typical employment interview, an employer makes a judgment about each applicant's abilities, using some internal scale. This internal scale is not well defined but allows the employer to evaluate prospective employees. The employer can be more certain, however, about the characteristics of the job and the type of person most likely to fill the job successfully. The employer's experience enables him or her to rank-order jobs based on the technical ability they require. This continuum forms a second scale. For example, an employer may judge that a particular person belongs to the upper 25 percent of applicants, as assessed on the internal aptitude scale. A particular job may be rated by the employer as belonging to the upper 25 percent of jobs on a scale of required technical ability. Having established the relative positions of both the job and the applicant on the two scales, the employer must judge their correspondence to each other. In this case, there appears to be a good match, and it is likely that the applicant will be offered the job.

The technical aptitude/job complexity component acts similarly to the evaluative techniques used by an employer. This utility function involves two scales: (1) a measure of a recruit applicant's overall technical aptitude, and (2) a measure of the Navy rating's difficulty or complexity. Thus, the conjunction of values determined by rank-ordering persons and ratings allows person-job matches to be evaluated as utility values.

The technical aptitude scale was established on the basis of factor analytic results (Shirkey, 1977). A technical aptitude factor emerged as a strong first factor in an analysis that involved 1000 subjects responding to ASVAB test items. This analysis was supported by previous findings in the literature, which also reported a strong technical aptitude first factor (Fletcher & Ree, 1976). The technical aptitude factor is a composite of four ASVAB subtest scores: (1) mechanical comprehension, (2) shop information, (3) electronics information, and (4) general science. The equation employed is:

$$A_i = 40.0 + 60 \frac{(C_i - 180)}{(280 - 180)} \qquad (2)$$

where:

A_i is the technical aptitude corresponding to the i'th person, and

C_i is the technical aptitude composite of four ASVAB subtest scores for the i'th person.

The job complexity scale was established using paired comparison methodology. Initial scale values were produced for the 86 ratings by applying the paired comparison procedure to two data sets: (1) experimenter judgments about the cognitive skills required by the 86 ratings (Marquardt & McCormick, 1973), and (2) experimenter estimates of the visual perceptual attributes required. Data were then collected from 22 Navy enlisted rating managers who were asked to compare the job complexity of small groups of ratings. These managers ranked the complexity of 8 to 10 jobs in pairs, thus contributing to a matrix from which new scale values could be derived for all 86 ratings. The scale was

then modified by using an iterative procedure to revise psychological values (Kroeker, 1982).

The raw technical aptitude/job complexity utility score associated with assigning person $\underline{i}$ to job $\underline{j}$ is given by the following equation:

$$\begin{aligned} Y_{ij} = 30.0 &- (0.0005)(A_i - 100)^2 + (1.867)(D_j - 35) \\ &- (0.00001696)(A_i - 100)^2 (D_j - 35)^2 \\ &- (0.0001867)(A_i - 100)^2 (D_j - 35) \\ &- (0.01244)(D_j - 35)^2 \end{aligned} \tag{3}$$

where:

Y_{ij} is the raw utility score of assigning person i to rating j,

A_i is the technical aptitude score for person i, and

D_j is the complexity index value for rating j.

A graph of this equation is given in Figure 1.

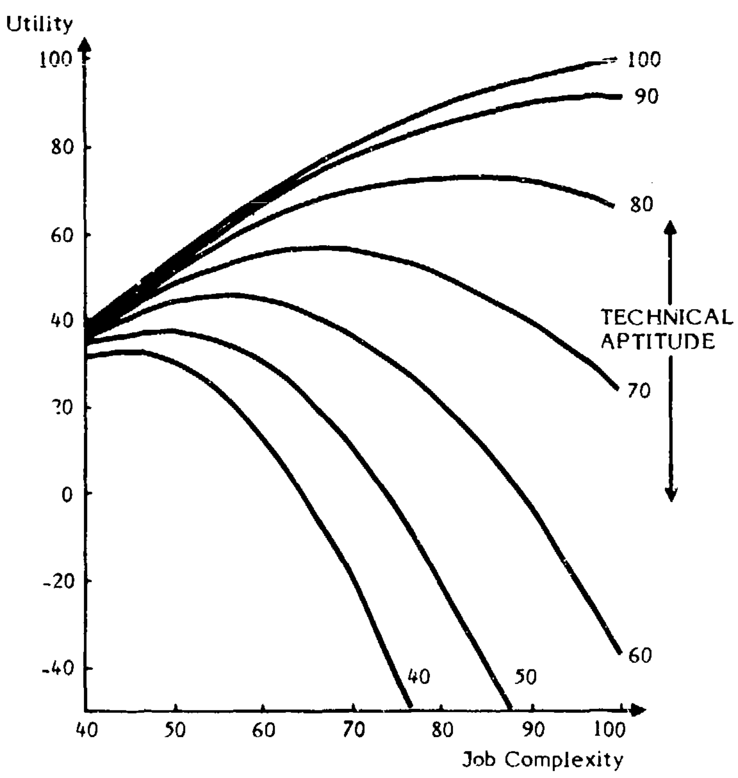


Figure 1. Utility vs. job complexity at constant aptitude levels.

The uppermost curve on the graph represents utility values for the highest level of technical aptitude (100) across the entire range of job complexity. The fact that this curve's maximum region occurs at the upper end of the complexity scale implies a tendency for the utility function to assign highly able persons to demanding jobs. The curve slopes downward gently from the region of demanding jobs to less demanding ones. This gradual downward slope implies that, although it is less likely for a highly able person to be assigned to less demanding jobs, it is clearly possible that such assignment may occur, given Navy priorities or individual preferences.

The lowest curve represents utility values for the lowest level of aptitude (40) across the entire range of job complexity. Its maximum region occurs at the lower end of the complexity scale; the sharp downward slope in the direction of increasing job complexity implies that lower ability applicants will almost always be assigned to less complex jobs. The central curve indicates that an applicant of average ability (70) will have a reasonable chance to be assigned to all jobs. Given the shape of the utility curve, it is most likely that he would be assigned to a rating in the intermediate complexity range.

The final utility calculation used by the procedure was obtained by the following equation:

$$U_{ij} = mP + Q \frac{Y_{ij}}{\sigma_Y} \tag{4}$$

where:

U_{ij} is the aptitude/complexity utility associated with person i and rating j,

Y_{ij} is the raw utility score for person i and rating j,

σ_Y is the SD of the population of Y_{ij} scores, and

m, P, and Q are constants.

Navy Priority/Individual Preference Component

The purpose of this component is to incorporate both Navy priorities and individual preferences when assigning recruit applicants to ratings. These two sets of objectives may be incompatible, particularly if both are described by utility functions allowed to vary independently. For example, the gain in utility resulting from an expression of strong preference for a particular rating may be offset by a loss in utility if the rating has a low Navy priority.

To overcome the deficiency of a strictly additive model, an interactive utility function was designed. Thus, a utility value is obtained as a function of the Navy priority index value for a particular rating in conjunction with the specified preference value of an applicant for that rating. To address both Navy priority and individual preference, two scales were derived:

1. Priority scale. Navy priorities were obtained from the career reenlistment objectives listed by the Office of the Chief of Naval Operations. These priorities were

augmented and modified using rating popularity and rating size as variables in a least-squares regression analysis. The resulting priority scale was refined by data collected from 10 Navy personnel managers concerned with setting recruiting goals and "A" school priorities. In a procedure similar to that used to establish the job complexity scale, these officers compared the relative importance to the Navy of small groups of ratings, by pairs. As with the job complexity scale, values were then further modified using a procedure to revise estimates of psychological scale values (Kroeker, 1982).

2. Individual preference scale. This scale was established and applied to 14 occupational categories. Rating preferences were grouped by occupational category, because recruit applicants do not have time to rank-order all 86 ratings, even if they have full information about the entire set.

The preference point allocation procedure allows each applicant to select the 5 most desirable of the 14 occupational groups, rank-order these 5 groups, and indicate his interest in each group on a 3-point scale. The preference point equation is given by:

$$P(n) = 60.0 + \frac{(40.0)I(n)R(n)}{(I_{max}R_{max} - I_{min}R_{min})} \qquad n=1, 2, 3, 4, 5 \tag{5}$$

where:

$P(n)$ is the preference value associated with any rating in the n'th occupational group,

$I(n)$ is the interest index value of the n'th group,

I_{min}, I_{max} are the interest index values associated with the lowest and highest ranked occupational groups respectively, and

R_{min}, R_{max} are the rank values associated with the lowest and highest ranked occupational groups respectively.

For each of the five occupational groups an applicant selects, the preference point value is the same for each rating in the group. For each of the remaining nine occupational groups, the ratings are assigned a constant value near the lower end of the preference point scale.

Given the Navy priority index value for a rating and the individual preference point value for that rating, the priority/preference utility corresponding to the person-job match was obtained from the following equation:

$$\begin{aligned} V_{ij} = 90.0 &+ (0.001)W_j^2 + (1.8)(Z_{ij} - 100) \\ &- (0.0000014)W_j^2 (Z_{ij} - 100)^2 \\ &- (0.00018)W_j^2 (Z_{ij} - 100) \\ &+ (0.009)(Z_{ij} - 100)^2 \end{aligned} \tag{6}$$

where:

V_{ij} is the priority/preference utility associated with placing person i in rating j,

W_j is the Navy priority index value corresponding to the j'th rating, and

Z_{ij} is the individual preference point value of person i for rating j.

A graph of Equation 6 is presented in Figure 2. The uppermost curve on the graph represents utility values corresponding to the highest level of Navy priority across the entire range of individual preferences. While strong or moderate preference for a high priority rating yields a high utility value, a low preference for the high priority rating nevertheless yields a moderate level utility that expresses the importance to the Navy of meeting "A" school quotas. The lowest curve on the graph represents utility values corresponding to the lowest level of Navy priority across the range of preference values. A strong preference for a low-priority rating results in a high utility because of the Navy's attempt to honor the applicant's expression of strong preference. A moderate degree of preference for that rating, however, results in a relatively low utility value because the Navy's best interests are not served by such assignment. An expression of no preference for a low-priority rating results in the lowest possible level of utility because neither the applicant's nor the Navy's interests are served.

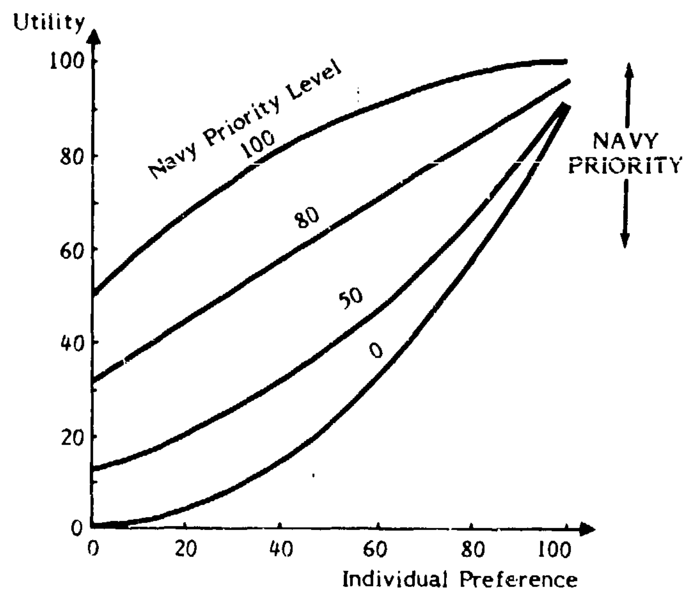


Figure 2. Utility vs. individual preference at constant priority levels.

The final utility calculation used by the procedure is defined by the following equation:

$$U_{ij} = mP + Q\frac{V_{ij}}{\sigma_V} \tag{7}$$

where:

U_{ij} is the priority/preference utility associated with person i and rating j,

V_{ij} is the raw utility score for person i and rating j,

σ_v is the SD of the population of V_{ij} scores, and

m, P, and Q are constants.

Minority Fill-rate Component

With PRIDE, minority group members were assigned in disproportionately large numbers to a few ratings and in small numbers to many others. The minority fill-rate component was designed to provide a uniform acquisition rate of minority group members for each rating. (A uniform rate of nonminority acquisitions was also implied.) The goal was for the proportion of minority group members in any rating always to equal the previously specified goal of the minority group proportion for the rating.

The difference between the actual and desired minority group proportions at any given time was used to indicate the status of the uniform fill-rate objective and was employed as the driving mechanism of a feedback function. The function compensates for existing conditions either by awarding additional utility points when the actual minority proportion is less than desired, or by subtracting utility points in the opposite case (see Figure 3).

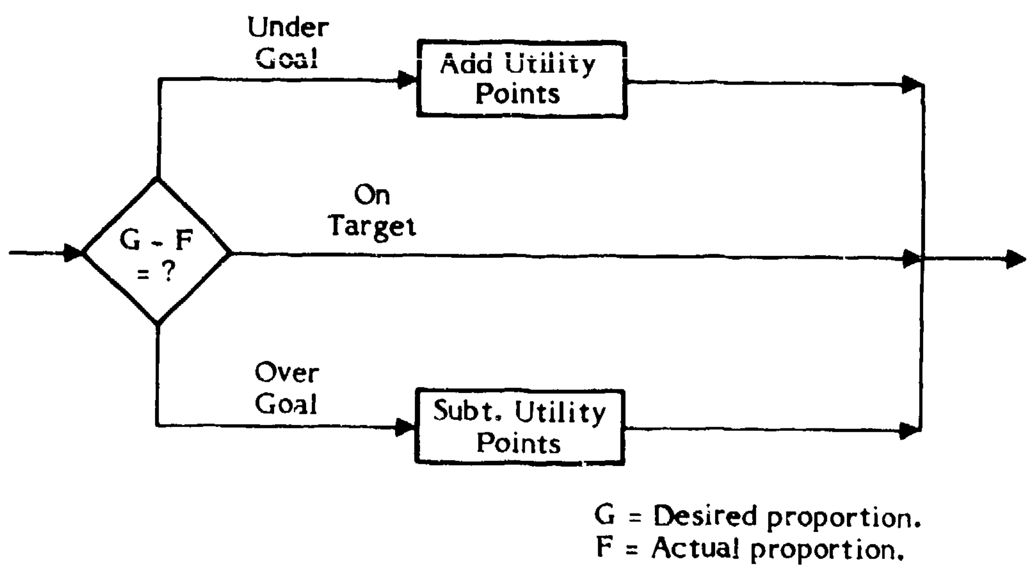


Figure 3. Minority fill-rate feedback mechanism.

The equation defining the feedback function is given by:

$$X_{jt} = (G_j - F_{jt})I \quad (8)$$

where:

X_{jt} is the proportion difference associated with rating j at time t,

G_j is the desired minority proportion for rating j,

F_{jt} is the actual minority proportion within rating j at time t, and

I is an indicator variable assuming the value +1 for minority group members and -1 otherwise.

The minority fill-rate utility function was governed strictly by the difference in proportions observed within rating j at any given time t. The equation corresponding to this utility function was given by:

$$Y_{ijt} = mP + sQ\,\frac{X_{jt}}{G_j} \tag{9}$$

where:

Y_{ijt} is the minority fill-rate utility for person i with respect to rating j at time t,

X_{jt} is the proportion difference within rating j at time t),

G_j is the desired minority proportion within rating j, and

m, s, P, and Q are constants.

Fraction Fill-rate Component

With PRIDE assignments, the end of any recruiting month was typically marked by a flurry of recruiting activity aimed at filling a substantial number of positions in certain ratings, largely because there was no systematic assignment procedure to acquire personnel at a uniform rate within ratings. From a managerial perspective, a procedure resulting in a uniform rate of acquisition is highly desirable. The fraction fill-rate component was designed to compare the proportion of applicants assigned to a particular rating with the average proportion of applicants assigned to all ratings at that time. If the proportion for the rating in question is below the average, additional utility points are awarded to influence the applicant to select that rating. If he does, the rating proportion moves closer to the average value.

Similarly, utility points are removed when the proportion of applicants assigned to a rating exceeds the average value. If another rating is selected instead, the resulting average proportion value increases slightly, thereby moving toward the value of the rating proportion. The operational part of the utility function is given by the equation:

$$T_{jt} = B_t - F_{jt} \tag{10}$$

where:

T_{jt} is the difference in proportions for rating j at time t,

B_t is the weighted average of proportions across all ratings at time t, and

F_{jt} is the proportion of applicants that have been assigned to openings within rating j up to time t.

The fraction fill-rate utility function was represented by the following equation:

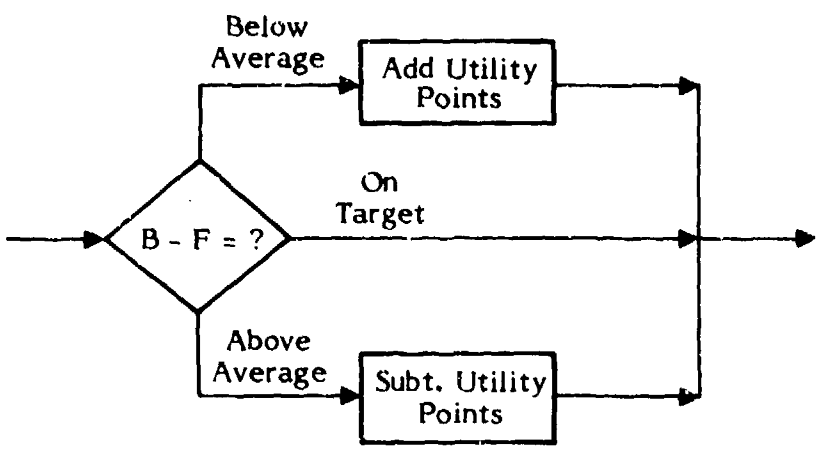
$$Y_{ijt} = mP + r\,Q\,T_{jt} \tag{11}$$

where:

Y_{ijt} is the fraction fill-rate utility given to person i with respect to rating j at time t,

T_{jt} is the difference in proportion for rating j at time t,
and m, r, P, and Q are constants.

The fraction fill-rate component acts as a feedback mechanism driven by the discrepancy between the fill proportion for a specific rating and the average proportion. Its advantage lies in the fact that it is not directly time-dependent, relying instead on the feedback characteristics to accomplish a uniform rate of accession across ratings. It is important to note that the procedure does not presuppose a uniform rate of fill across time but, rather, accommodates any prospective applicant arrival rate (see Figure 4).



B = Weighted average of proportions.
F = Actual proportion.

Figure 4. Fraction fill-rate component.

Composite Utility

The five components are weighted to conform to Navy policy (see Table 1).[1] When the weighted utilities are combined, the resulting single numerical value, the composite utility, describes the merit of assigning a specific person to a specific rating.

Table 1

Component Weights for the CLASP Composite Utility

Component	Weight
School success	.30
Technical aptitude/job complexity	.40
Navy priority/individual preference	.15
Minority fill-rate	.08
Fraction fill-rate	.07

Note. The scaling procedures resulted in expression of the school success, priority/preference, and aptitude/complexity utilities in the same metric. Because the remaining two utility components possessed associated metrics highly similar to it, a common metric was assumed for all components.

Formation of a composite utility allows the value of placing a person in a rating to be expressed as a single index. In general, the expression for a composite utility value consisting of five weighted components is written:

$$S_{ij} = \sum_{k=1}^{5} L_k U_{ijk} \quad , \quad \sum_{k=1}^{5} L_k = 1 \tag{12}$$

[1] The component weights were empirically derived according to the following criteria:

1. The raw utility scores for the first two components were examined and it was observed that the variance of the aptitude/complexity scores was affected by a number of extreme values. For the center of the scale to function effectively in discriminating between persons, it was decided that the variance of the weighted aptitude/complexity component would be allowed to assume a larger value than that of the weighted school success scores, but that it should not be larger by more than a ratio of 3:2. Weights of 0.30 and 0.4 for the school success and aptitude/complexity components respectively met this criterion.

2. It was stipulated that the priority/preference component should carry approximately the same weight (0.15) as the combined minority and fraction fill-rate components. The minority fill-rate component was given slightly more weight than the fraction fill-rate component, resulting in weights of 0.08 and 0.07 respectively.

where:

S_{ij} is the composite utility associated with assigning person i to rating j,

U_{ijk} is the utility associated with person i for rating j on component k, and

L_k is the decision maker's weight associated with component k.

Decision Index Procedure

In CLASP assignments, every recruit applicant is initially considered a potential candidate for every rating and receives a composite utility score for each one. Each composite utility score, obtained by calculating the value of the five utility components and weighting them as described earlier, is compared with the average composite utility or the decision index mean value for each rating; the difference is called the decision index (DI) score (McWilliams, 1970; Ward, 1959). Thus, a DI score is calculated for every possible person-job combination.

The DI score is calculated as follows: In a matrix S having I rows (person) and J columns (ratings) and in which the elements S_{ij} are composite utility values corresponding to the $\underline{i}$'th person and the $\underline{j}$'th rating, any composite utility value may be written:

$$S_{ij} = S_{..} + (\bar{S}_{i.} - \bar{S}_{..}) + (S_{.j} - \bar{S}_{..}) \tag{13}$$
$$+ (S_{ij} - \bar{S}_{i.} - \bar{S}_{.j} + \bar{S}_{..})$$

The only part of this expression carrying information concerning the suitability of person i for rating j is the far right-hand term. For a fixed value of i (i.e., for a given person), the far right-hand term contains only two variable quantities, S_{ij} and $\bar{S}_{.j}$. Rewriting the term produces:

$$S_{ij} - \bar{S}_{i.} - \bar{S}_{.j} + \bar{S}_{..} = S_{ij} - \bar{S}_{.j} - K \tag{14}$$

for a fixed value of i and where K is a constant. The expression

$$DI = (S_{ij} - \bar{S}_{.j}) \tag{15}$$

forms the operational part of the procedure. Recall that S_{ij} represents the composite utility associated with assigning person i to rating j, and $\bar{S}_{.j}$ represents the mean composite utility for rating j across all persons.

The DI mean, $\bar{S}_{.j}$, for a given recruiting month forms the basis for the subsequent operation of the optimal-sequential assignment procedure. Changing the set of DI means in the procedure yields different assignments. (DI means for the July 1977 data set appear in Appendix B.) When recruit applicant population characteristics do not change across months, a highly stable DI mean configuration results, with minimal disturbances occurring in the assignment system. However, when the characteristics change radically, it is necessary to adjust the DI mean profile to operate the procedure at maximum efficiency.

After DI values are calculated for all ratings for each person, they are ranked from highest to lowest. The highest DI value identifies the rating for which a person compares most favorably with the population of qualified individuals. Because the DI values can be difficult to interpret, an optimality index (OI) was developed to assist classifiers with comparisons.

Optimality Index

To facilitate comparisons among ratings, the DI values were rescaled to a common metric by means of the following equation:

$$R_{ij} = 50 + 20 \frac{(S_{ij} - \bar{S}_{\cdot j})}{\sigma_i} \tag{16}$$

where:

R_{ij} is the rescaled value of rating j for person i,

$(S_{ij} - \bar{S}_{\cdot j})$ is the DI for person i with respect to job j, and

σ_i is the SD of the DI values for person i.

When the largest R_{ij} value for person i is represented by R_{max}, the second rescaling involves only a translation of the origin and is given by the equation:

$$\Phi_{ij} = R_{ij} + (100 - R_{max}) \tag{17}$$

where:

Φ_{ij} is the optimality index value associated with rating j for person i.

The OI allows ratings positioned at different points along the scale to be compared easily. Setting the largest OI to an arbitrary value of 100 defines a convenient frame of reference to help classifiers underscore the need for selecting options near the top of the ratings lists when they discuss these lists with recruit applicants.

List Presentation Strategy

OI scores enable the rating options for each recruit applicant to be ordered so that the highest ranked is the optimal rating for the applicant because its relative utility is greatest. After rank-ordering, the list of ratings is reduced by removing all those for which an applicant does not qualify or for which there is no opening within the recruiting month in question.

Because the ultimate objective of the CLASP assignment procedure is acquiring persons who select optimal ratings, it is inefficient to expend significant resources in determining an ordered list of ratings for an applicant without a list presentation strategy that attempts to influence the applicant's choice. When a classifier presents the amended ratings list to an applicant, the optimal jobs, on the top of the list, would be discussed

first. Ideally, the applicant would select the first rating, which is associated with the maximum utility when individual and organizational objectives are considered jointly. In practice, however, the applicant would be likely to select a rating further down the list because he would be evaluating ratings solely from his own perspective. When the classifier and the applicant reach a compromise, a reservation is made for the rating agreed on by both people.

If an applicant rejected the ratings at the top and undertook a search lower on the list, the OI score might be so low at some point that the Navy would not be interested in assigning the person to such ratings because many other applicants could be identified as more suitable candidates. Even though a lower ranked rating may be desirable from a personal perspective, it may not be equally desirable from an organizational one.

Any particular list may have been affected by the deletion of ratings with filled quotas. Because some of these deleted ratings may be attractive to an applicant, it is worth considering rating options for a future recruiting month, in which the quotas may be unfilled.

Future Rating Options

A second list may be prepared that includes ratings available in future recruiting months (see Table 2). Rating options are displayed within a given recruiting month if the following criteria are met: (1) the quotas for the ratings are open, (2) the applicant qualifies for the ratings, and (3) the OI for each rating exceeds a specified minimum value.

Table 2

Rating Options Lists Ordered by Recruiting Month for a Hypothetical Recruit Applicant

Jan[a]	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Job D	Job C	Job B	Job A	.	.	.	.	.
Job H	Job D	Job C	Job B	.				
Job I	Job H	Job D	Job C	.				
Job N	Job I	Job G	Job D	.				
etc.								

[a]Current recruiting month.

Although the hypothetical applicant in Table 2 may qualify for jobs A, B, and C, they do not appear on the optimal ratings list for the current recruiting month because the quotas are filled. For this applicant, the jobs with the highest OIs appear in the lists farthest from the current recruiting month.

Significant benefit can accrue to the Navy if rating options from the top of the list can be secured for an applicant in a future recruiting month. To facilitate this process, CLASP allows rating options for as many as 12 months to be displayed at the computer terminal. A maximum of 15 rating options can be displayed for the current month, 10 options for the next month, and 5 options for each following month. Rating options chosen from future recruiting months are constrained to be among those bearing high OI values. Consequently, there is greater flexibility in rating options in the current month, at the risk of lower OI scores, while greater control and higher OI scores may be obtained in distant recruiting months.

CLASP and PRIDE Assignment Evaluation and Comparison

The simulation process applied to the July 1977 data set resulted in the allocation of 3,450 school seats. Sixty-six persons (1.9%) did not receive assignments, partly because of an artifactual constraint that is discussed on page 21, and partly because the data base included personnel for whom admission requirements had been waived and who could, therefore, not legitimately receive a simulation assignment.

Overall Assignment Quality

Table 3 displays the rating options list prepared for the first recruit on the simulation data tape. The OI defines the value of assigning this person to a specific rating. The table also enables comparisons between the quality of the assignment made under the CLASP and PRIDE procedures. In this example, the recruit was actually assigned through PRIDE as a sonar technician (ST) in the advanced electronics field (AEF) and hypothetically assigned through CLASP as an aviation electronics technician (AT) in the AEF group.

Table 3

Rating Options List for First Recruit on Simulation Data Tape

Rank	Rating[a]	Optimality Index (OI)
1[b]	AT (AEF)	100
2	DS (AEF)	94
3	ET (AEF)	93
4	EA	91
5	PE (AEF)	88
6	AT	86
7	AX (AEF)	86
8	FT (AEF)	84
9	MM (NF)	84
10	ET (NF)	84
11	EW (AEF)	83
12	JO	83
13[c]	ST (AEF)	82
14	AW	81
15	EM (NF)	81
16	AE	78
17	TD	76
18	MR	75
19	ET	75
20	AG	74

[a]AEF = Aviation electronics field, and NF = Nuclear field; titles of ratings are provided in Appendix A.

[b]CLASP assignment.

[c]PRIDE assignment.

A measure of agreement between the results of the CLASP and PRIDE assignment procedures and an ideal level of assignment quality was obtained using a weighted mean square (MS) statistic consisting of the weighted sum of squared deviations from an OI level of 100, divided by the total number of assignments made.

This measure yielded the following values: CLASP deviation MS = 749.6 and PRIDE deviation MS = 1337.4. The results indicated that the CLASP optimal-sequential procedure produced closer agreement with the assignment quality level desired by personnel planners. If a more realistic estimate of the highest average optimality attainable under operational conditions (e.g., the 1978 field test values of 92.6 or 89.0) had been used instead of the ideal value of 100, the MS statistical criterion would have favored the optimal-sequential procedure even more heavily.

The extent of potential improvement in assignment quality that can be achieved by using the optimal-sequential procedure was difficult to quantify. Figure 5 indicates potential improvement by displaying the frequency of improvement score categories. Depicted along the abscissa, these categories were based on the difference in optimality obtained under the two procedures for each assignment. The majority of cases demonstrated a moderate degree of improvement in assignment quality. The remainder, particularly those cases involving simulation assignments near the end of the recruiting period, demonstrated an inferior assignment.

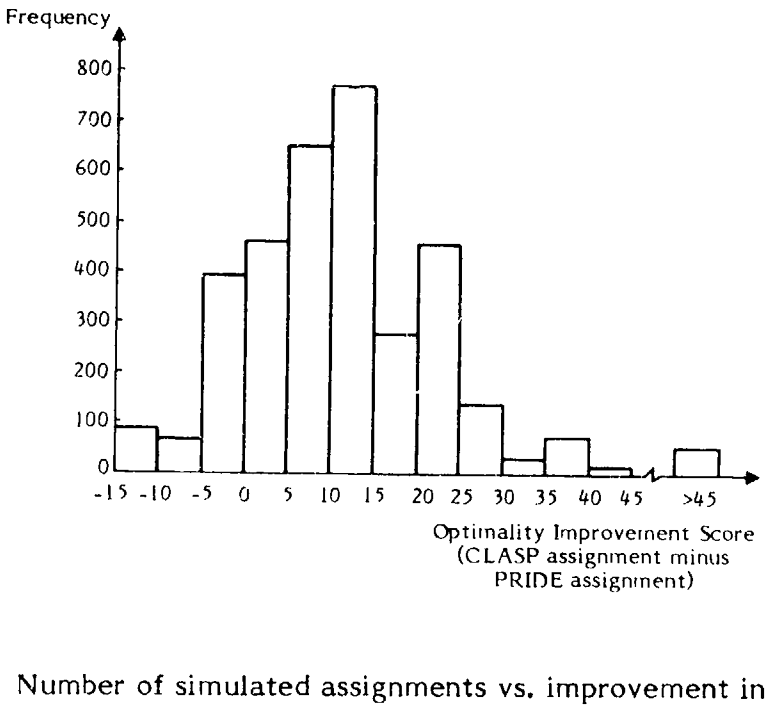


Figure 5. Number of simulated assignments vs. improvement in optimality.

Assignment Quality Over Time

The assignment simulation using the July 1977 data base demonstrated that overall assignment quality was best in the first month, when all positions were vacant, and deteriorated toward the end of the simulated time period, when very few positions remained unfilled. To explain this phenomenon, two indices of relative allocation effectiveness were defined. The first, labeled δ (assignment quality), was the difference in OI values between the optimal job on a list unconstrained by quotas and the best available job, the job whose OI value was largest on the list of available positions. The second index, ϵ (quality discrepancy), was the difference in OI values between the best available job and the one actually assigned under the PRIDE first-come, first-served procedure. The δ index was used to assess the performance of the CLASP optimal-sequential procedure as a function of time.

The average value of δ for each month was calculated from the simulated assignments made during that month. Figure 6 illustrates the deterioration of assignment quality over time as measured by δ. The relationship is described by a correlation of 0.96.

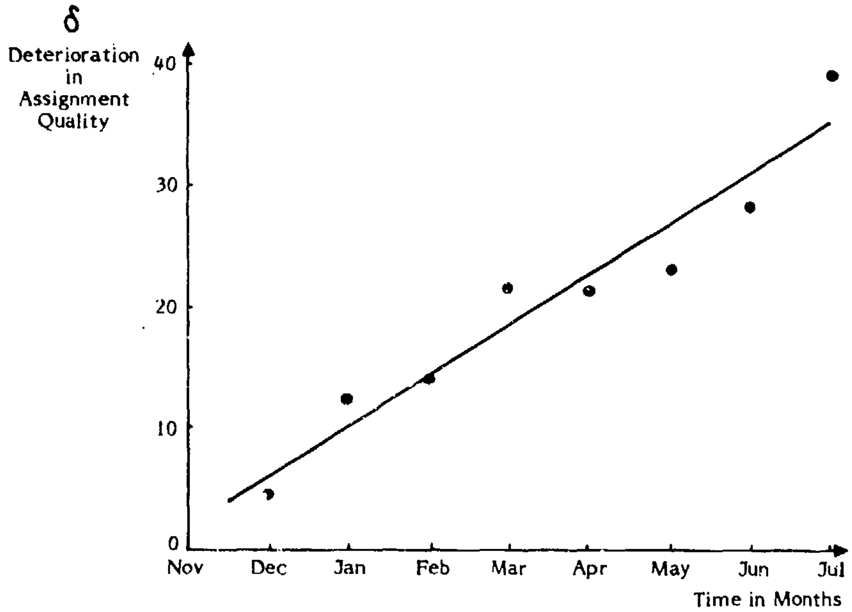


Figure 6. Deterioration in assignment quality over time.

The result shown in Figure 6 was affected by the simulation constraint that required everyone in the simulation sample to be assigned to openings available in July 1977. In practice, under a flexible delayed-entry program, there is no such last-minute need to fill the remaining positions with the limited number of available persons. Under real operating conditions, the population considered for the July 1977 openings and the likelihood of higher quality assignments would be increased.

This artifactual effect was most pronounced during the late stages of the CLASP simulation and may have accounted for the elevation of the July δ value in Figure 6 to a level of 1.5 standard error units above the predicted value.

An average ε value for each month was calculated from the difference in OI values between the simulated (CLASP) and actual (PRIDE) assignments. The graph in Figure 7 indicates that the difference in quality between the CLASP and PRIDE procedures, as measured by ε, decreased with time. The relationship was described by a correlation of -0.88.

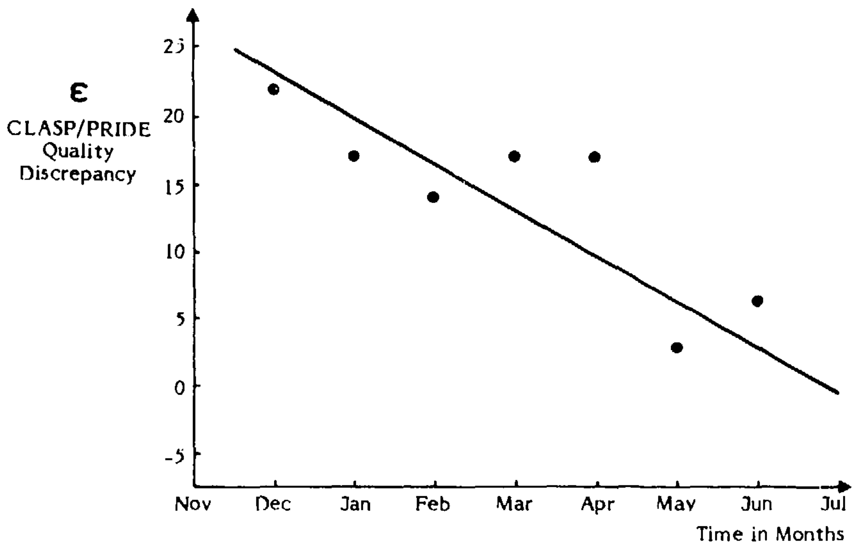


Figure 7. Reduction in quality discrepancy over time.

For the purpose of this research, assignment quality was defined in terms of high OI values that systematically represented policy considerations and consistently applied them to person characteristics and job properties. Within this frame of reference, the CLASP optimal-sequential procedure was a more effective mechanism for carrying out personnel acquisition policies than was the PRIDE first-come, first-served procedure. As indicated by the large positive ε value in Figure 7, CLASP was particularly effective at the outset of the recruiting period. Although ε assumed a value near zero during the last month, indicating that the two procedures were approximately equally effective near the end of the recruiting period, ε would not decrease so rapidly in a field recruiting situation as in this simulation. As previously noted, under real operating conditions, a larger number of potential candidates would be considered for the unfilled positions at the end of a recruiting period. Consequently, person-job matching for the last positions would be better and the final s value would be higher.

At the end of the simulated CLASP assignment, the observed ε value fell 1.3 standard error units below the predicted value (see Figure 7), implying substantially poorer quality assignments than under the PRIDE procedure. This effect, a result of force-fitting the late-arriving personnel to the remaining positions, was an artificial constraint impos^ʲ ʰv simulation and was of similar size to the discrepancy in δ values discussed earlier.

Assignment Quality vs. Recruiting Quotas

A number of performance comparisons between the CLASP and PRIDE procedures can be made using Figure 8, which depicts the relationship between average OI and percentages of the total quota that would be filled using six different assumptions. The actual assignment curve, labeled PRIDE, represents the average OI under first-come, first-served conditions. The remaining curves were generated using CLASP procedures. Curve 1 represents the average OI under the assumption that everyone selected the first (highest valued) job on the optimal list. Curves 5 through 20 use the assumptions that all persons chose the jobs ranked 5th, 10th, 15th, and 20th respectively.

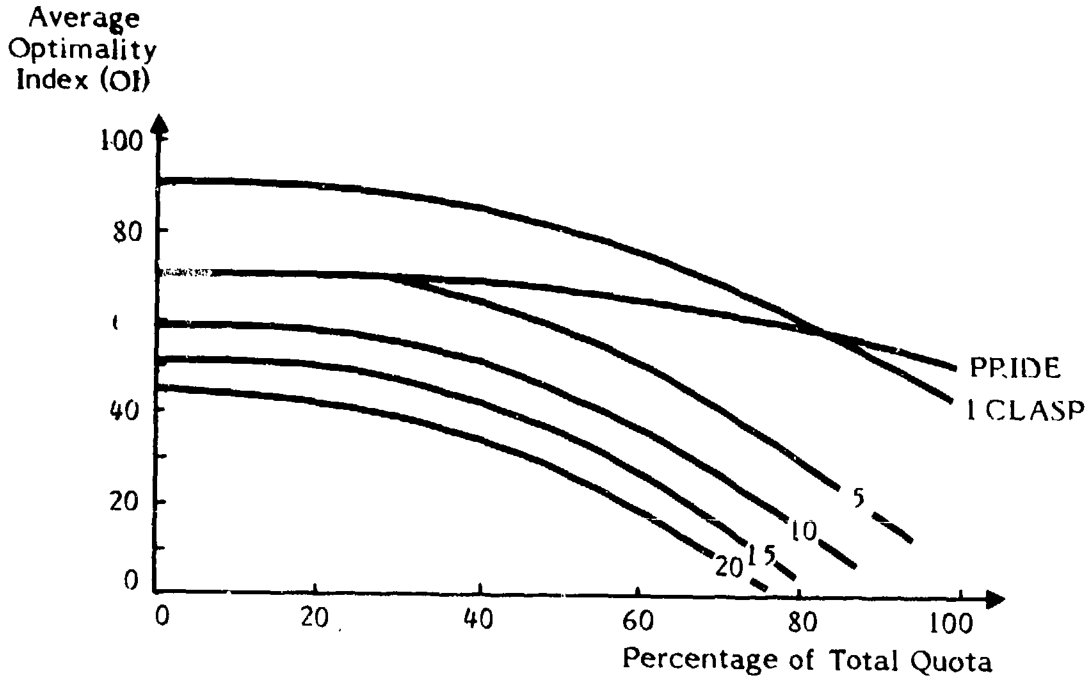


Figure 8. Optimality index vs. percentage of total quota filled using six assumptions.

In Figure 8, the horizontal axis does not represent a linear time scale. For example, there is a 5-week time interval between the 0 and 10 percent points on the abscissa but only a 3-week interval between the 90 and 100 percent points. The shape of the functions alters slightly when average optimality is plotted against time, the curves exhibiting slightly negative slopes for a longer portion of the horizontal axis than in Figure 8. The curves also display a more pronounced drop toward the axis at the end of the time period, primarily due to the artificial simulation constraint discussed previously.

The simulation-generated curves in Figure 8 display a marked decrease in the average optimality due to the force-fitting phenomenon near the end of the recruiting period, while the actual assignment curve (PRIDE) shows only a slight decline. Although it was somewhat more difficult to assign personnel at high optimality levels by the end of the simulated recruiting period, curves generated under normal operating conditions with the optimal-sequential assignment procedure are expected to exhibit at most a moderate decline.

As indicated in Figure 8, average optimality varied as a function of position on the optimal list, with assignment quality decreasing most rapidly among the top-ranked choices. In other words, dropping from the highest ranked to the 2nd job option had a more serious effect than descending from the 19th to the 20th. Under normal operating conditions, the average optimality of the top-ranked choice under CLASP is expected to exceed that of the average choice under PRIDE by as much as 20 points. Simulation constraints precluded determining more exact estimates.

The average OI values for each of the two assignment procedures are listed by job category (rating) in Table 4. It should be noted that the values obtained under the optimal-sequential procedure in the CLASP column are underestimates of the true values because of the simulation constraints mentioned earlier. Nevertheless, they usually exceed the average value obtained under the PRIDE first-come, first-served procedure. Several ratings with quotas of zero were not included in the analyses but are shown in Table 4 as part of the complete list.

Under actual operating conditions, recruit applicants would choose at various levels on the optimal list. Although no simulation results were available for a policy permitting different choice levels, the 1978 field test produced average choice levels ranging from 1.63 to 3.10 and corresponding average OI values ranging from 90.0 to 85.7 (see Table 5). The average OI value of 87.3 and average rank of 2.24 are consistent with the data in Figure 8. The data in Table 5 are also in close agreement with those reported by CNRC for a 1980 field test, in which an average rank of 2.77 was obtained, with 57 percent of the recruit applicants selecting the highest ranked job on the ordered lists.[2]

"A" School Attrition Cost

The potential effectiveness of the CLASP procedure was partially assessed with respect to "A" school attrition cost. Table 6 presents Navy ratings ranked by improvement potential, which is the difference between average OI scores under CLASP and PRIDE procedures as calculated from the simulation data set, and "A" school attrition cost as calculated by Middleton, Rankin, Green, and Papetti (1977). The correlation between the two sets of ranks was 0.39, suggesting that improved matching of persons to jobs may be a significant factor in the ultimate reduction of attrition and attrition cost.

Fraction and Minority Fill Rates

To fill a given rating's quota at a uniform rate within a given shipping month, the CLASP fraction fill-rate component allocates utility points to increase or decrease emphasis on that job category. A typical simulation graph showing the relationship between the proportion of advanced electronic technician (ETAE) positions filled with qualified applicants and time remaining until the shipping month is presented in Figure 9. The fraction fill-rate function in this illustration corrects for the relative deficiency during the early months, numbered 11 through 8, and for the relative oversupply during the later months, numbered 4 through 0.

The operation of the minority fill-rate function displays similar characteristics. However, the corrections appear more drastic because the relative discrepancies between actual and desired proportions are affected to a greater degree by a single additional accession in a job category with a small goal. For example, when a target goal of four

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[2]Black, CDR J.H. CNRC-24. Personal communication, March 1981.

Table 4

Average OI Values Under CLASP and PRIDE Assignment Procedures
(N = 3,516)

Rating[a]	CLASP	PRIDE	Quota	Rating[a]	CLASP	PRIDE	Quota
AB	74.6	65.9	53	EWAE	78.0	63.5	20
AC	92.0	66.0	16	FT	91.3	65.6	31
AD	71.6	60.6	79	FTAE	93.3	72.3	51
AE	81.8	68.7	80	GM	62.2	52.5	99
AG	98.4	73.7	10	GMT	86.5	61.4	17
AK	92.2	74.0	12	HM	71.2	68.1	225
AM	66.8	64.4	162	HMAT	83.2	83.2	16
AO	71.9	62.0	69	HT	72.0	62.4	125
AQ	98.2	39.3	10	HTAT	66.4	68.3	7
AQAE	99.3	67.0	10	IC	71.1	72.7	18
AS	88.3	72.9	14	ICAT	66.8	49.8	17
AT	91.8	73.4	38	ICNF	59.5	56.2	46
ATAE	98.8	78.0	43	IM	74.5	80.2	4
AW	86.5	69.5	25	IS	86.4	77.5	11
AX	95.6	79.3	12	JO	99.9	94.2	5
AXAE	98.3	64.7	12	ML	00.0	00.0	0
AZ	88.8	49.2	12	MM	51.3	52.0	66
BT	42.3	55.4	87	MMNF	64.7	65.6	247
BTAT	00.0	00.0	0	MN	90.4	55.4	5
BU	77.4	63.6	11	MR	81.4	62.0	24
CE	86.5	64.7	12	MS	83.3	62.8	85
CM	78.3	70.2	12	OM	99.0	89.4	5
CTA	87.7	68.3	3	OS	57.7	49.2	102
CTI	85.9	66.0	22	OT	84.3	56.4	9
CTAE	90.1	55.7	18	PC	96.2	57.3	13
CTO	85.3	56.4	18	PEAE	79.0	69.8	65
CTR	80.0	70.2	26	PH	68.5	56.2	14
CTT	98.9	70.7	11	PM	76.5	80.0	4
DK	86.0	64.5	8	PN	94.0	57.0	27
DP	93.0	71.2	14	PR	87.4	48.7	16
DSAE	94.8	84.8	23	QM	70.8	57.8	61
DT	94.6	81.9	11	RM	90.8	70.8	187
EA	77.6	74.9	12	RMAT	85.1	24.3	21
EM	58.7	62.0	38	SH	91.0	72.1	38
EMAT	00.0	00.0	0	SK	82.0	71.7	57
EMNF	81.9	71.5	72	SM	92.9	00.0	22
EN	84.3	68.2	52	ST	64.1	59.3	15
ENAT	89.1	66.9	8	STAE	64.9	70.4	63
EO	87.6	58.3	20	SW	72.8	49.9	8
ET	93.6	77.2	8	TD	97.9	82.8	11
ETAE	77.2	69.2	157	TM	75.0	67.8	42
ETNF	71.2	66.4	191	UT	74.1	77.9	15
EW	92.7	66.3	7	YN	91.8	79.7	38

[a]Titles of ratings are provided in Appendix A.

Table 5

1978 Field Test Assignment Results

Site	N	Average Optimality Index (OI)	Average Choice on Rating List
Phoenix	30	90.0	1.64
Oakland	64	86.6	3.10
Boston	81	88.1	2.38
Chicago	10	90.6	2.80
Minneapolis	39	79.9	2.11
Des Moines	19	85.7	2.40
Houston	34	88.5	2.00
Miami	64	90.9	1.63
Total	341	---	---
Overall Average	---	87.3	2.24

Table 6

Sixty-five Navy Ratings Ranked by Improvement Potential and Attrition Cost

Rating	Improvement[a] Potential	Attrition[b] Cost	Rating	Improvement[a] Potential	Attrition[b] Cost
SM	1	34	EN	33	46.5
AQ	2	19	AS	34	59
AZ	3	32	TD	35	13
PR	4	23	AE	36	35
PN	5	14	QM	37	58
MN	6	6	PH	38	8
CATE	7	16	YN	39	15
AXAE	8	11	AD	40	33
AQAE	9	10	EMNF	41	38.5
EO	10	52	SK	42	65
CTO	11	17	AO	43	43
CTT	12	4	CTR	44	3
OT	13	26	GM	45	31
EW	14	1	HT	46	63
AC	15	5	IS	47	44.5
FT	16	9	AB	48	57
AG	17	24	OS	49	30
SW	18	50	CM	50	53
CE	19	46.5	ETAE	51	27
DP	20	49	TM	52	56
DK	21	61	ETNF	53	38.5
ATAE	22	21	ST	54	48
MS	23	54	ICNF	55	38.5
RM	24	25	EA	56	64
CTA	25	7	AM	57	36
MR	26	44.5	MM	58	41
SH	27	60	MMNF	59	38.5
AT	28	18	IC	60	55
AK	29	62	EM	61	28
AW	30	20	PM	62	42
ET	31	2	UT	63	51
AX	32	12	IM	64	22
			BT	65	29

[a]Improvement potential rank is based on the difference between average optimality index (OI) scores under CLASP and PRIDE procedures.

[b]Attrition cost values represent total "A" school attrition cost, scaled in proportion to the size of the rating (Middleton, Rankin, Green, & Papetti, 1977).

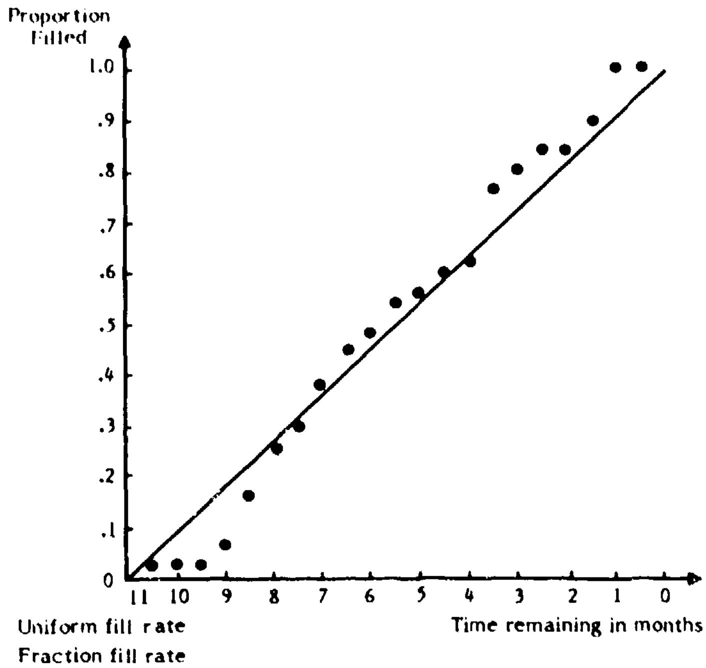

Figure 9. Proportion of ETAE positions filled vs. time remaining to shipping date.

minority members is desired, each accession changes the actual proportion by a value of 0.25. More often than not, the actual proportion would either overshoot or undershoot the desired proportion, and the corresponding utility calculation follows this fluctuation. Appropriate damping mechanisms are available to reduce the sensitivity of the function as desired.

The effectiveness of the minority fill-rate component under simulation conditions can be evaluated using a number of criteria, the most important being the proportion of minority group members assigned to each rating. Table 7 shows the percentage of minority recruits assigned under simulation conditions by CLASP and the actual minority proportions assigned by PRIDE. As shown in Table 7, the minority fill-rate component influenced the allocation process so that the CLASP procedure achieved a minority proportion closer than PRIDE to the target value (6%) in 33 of 86 job categories. The two procedures performed equally well in 38 categories, and the PRIDE procedure achieved values closer to the target in the remaining 15 categories.

The degree of correspondence between the desired minority proportion and the actual proportion obtained under either procedure was measured using a sum of squares (SS) statistic, based on the discrepancy between the minority ratio by either procedure and the target ratio, and weighted by the total number of persons assigned in each category. It yielded the following values: CLASP discrepancy SS = 5.38, and PRIDE discrepancy SS = 10.64. The statistic assumed a value of zero if each job category was filled with minority group members up to the target level. The results indicated that the CLASP procedure was more effective than PRIDE with respect to attaining desired minority ratios.

Table 7

Minority Ratios Obtained Under CLASP and PRIDE Assignment Procedures

Rating[a]	Rating Quota (N)	Minority Recruits Assigned: CLASP (%)	Minority Recruits Assigned: PRIDE (%)	Rating[a]	Rating Quota (N)	Minority Recruits Assigned: CLASP (%)	Minority Recruits Assigned: PRIDE (%)
AB	53	10	12	EWAE	20	5	5
AC	16	6	6	FT	31	3	0
AD	79	9	6	FTAE	51	2	6
AE	80	1	8	GM	99	10	7
AG	10	0	0	GMT	17	6	6
AK	12	8	8	HM	225	12	11
AM	162	8	7	HMAT	16	6	6
AO	69	6	16	HT	125	8	2
AQ	10	10	0	HTAT	7	0	0
AQAE	10	10	0	IC	18	11	6
AS	14	0	0	ICAT	17	6	0
AT	38	0	3	ICNF	46	2	2
ATAE	43	2	7	IM	4	0	0
AW	25	0	0	IS	11	0	0
AX	12	0	0	JO	5	0	0
AXAE	12	0	8	ML	0	0	0
AZ	12	0	17	MM	66	8	3
BT	87	6	3	MMNF	247	3	2
BTAT	0	0	0	MN	5	0	0
BU	11	0	0	MR	24	4	0
CE	12	8	0	MS	85	13	8
CM	12	8	0	OM	5	0	0
CTA	3	0	33	OS	102	10	2
CTI	22	5	0	OT	9	0	0
CTAE	18	0	11	PC	13	0	15
CTO	18	6	0	PEAE	65	3	0
CTR	26	12	12	PH	14	7	8
CTT	11	9	11	PM	4	0	0
DK	8	12	0	PN	27	7	27
DP	14	14	8	PR	16	0	0
DSAE	23	4	13	QM	61	5	7
DT	11	0	27	RM	187	9	14
EA	12	0	0	RMAT	21	5	5
EM	38	10	5	SH	38	13	17
EMAT	0	0	0	SK	57	10	14
EMNF	72	0	0	SM	22	9	0
EN	52	4	2	ST	15	0	0
ENAT	8	0	0	STAE	63	3	3
EO	20	0	0	SW	8	12	14
ET	8	0	0	TD	11	9	9
ETAE	157	5	4	TM	42	10	17
ETNF	191	2	1	UT	15	7	0
EW	7	14	14	YN	38	5	16

[a]Titles of ratings are provided in Appendix A.

CONCLUSIONS

CLASP provides decision-makers with an improved tool for personnel classification and placement. It enables managers to make personnel decisions with both greater. accuracy and greater concern for individual applicants. Under both field test and simulation conditions, the CLASP optimal-sequential assignment procedure assigned personnel more effectively to optimal ratings than did the PRIDE first-come, first-served procedure. In addition, CLASP minority ratios more closely approximated specified target ratios, and "A" school seat allocation proceeded at a more uniform rate under all conditions tested.

Comparisons between the CLASP and PRIDE procedures were frequently based on scale values derived from systematic application of utility functions that embody policy considerations determined by Navy decision-makers. Therefore, the CLASP optimal-sequential procedure, which depends on these functions, was clearly superior to the PRIDE first-come, first-served procedure. PRIDE was less effective because policy matters handled at the local district level receive support from a restricted data base and because local decisions may not consider broader national concerns. For example, a particular classifier, familiar with a small subset of ratings, may influence most recruit applicants to select from that subset. CLASP makes it possible to measure the effectiveness of certain assignment policies and the consequences of various tradeoff decisions.

A general CLASP rule-of-thumb is to assign a recruit applicant to the highest rating on the ordered list because a higher ranked job results in greater payoff to the Navy. In view of the fact that payoff is also dependent on the candidate's preferences and abilities, the choice of a highly ranked position is also in his best interest. Other personal and system benefits, such as improved job satisfaction, morale, and reenlistment rates, are also expected but could not be supported by data collected in this research.

It is anticipated that the operation of the CLASP optimal-sequential assignment procedure and the monitoring capability it affords will result in a substantially reduced number of ghost reservations. The effective operation of the PRIDE system was impaired by operators securing highly desirable school seats for nonexistent recruits (making ghost reservations) in the hope that, when suitable candidates were found, substitute reservations could be made and enlistment contracts could be expeditiously signed. Although this practice of system manipulation benefited a few recruiters, it harmed the system by withholding potential sales and by producing unreliable accession statistics. Except for the fraction and minority fill-rate functions, the utility calculations in CLASP are largely independent of time and therefore yield similar OI values regardless of an applicant's time of entry into the system. Thus, the CLASP procedure will make ghost reservations a less lucrative, more risky proposition.

This study was not designed to collect data to answer questions about attrition. However, the results indicated that improved matching between persons and jobs, as accomplished by CLASP, may be a significant factor in the ultimate reduction of attrition and attrition cost.

RECOMMENDATIONS

It is recommended that the Naval Military Personnel Command (NMPC-48):

1. Monitor CLASP to assess the performance of both the assignment system and the recruiters and classifiers who use it. Multivariate approaches that incorporate more behavioral aspects of the career decision process would be examined by NAVPERSRANDCEN.

2. Continue its ongoing efforts to use CLASP as a vehicle for assessing the quality of Navy person-job matches.

3. Evaluate the requirement for extending the model to encompass more components and to assign additional groups. An attrition component presently under development would be evaluated for inclusion. The model would be extended to include women, a change that will require development of new criteria and school success prediction equations.

It is recommended that NAVPERSRANDCEN (1) monitor the model's operating characteristics under a variety of conditions, and (2) conduct a sensitivity study to ascertain the degree of stability of solutions generated under the optimal-sequential procedure.

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APPENDIX A

TITLES AND ABBREVIATIONS FOR 86 NAVY RATINGS

Table A-1

Titles and Abbreviations for 86 Navy Ratings

Rating Title	Abbreviation
Aviation boatswain's mate	AB
Air traffic controller	AC
Aviation machinist's mate	AD
Aviation electrician's mate	AE
Aerographer's mate	AG
Aviation storekeeper	AK
Aviation structural mechanic	AM
Aviation ordnanceman	AO
Aviation fire control technician	AQ
Aviation fire control technician, advanced electronics field	AQAE
Aviation support equipment technician	AS
Aviation electronics technician	AT
Avionics technician, advanced electronics field	ATAE
Aviation antisubmarine warfare operator	AW
Aviation antisubmarine warfare technician	AX
Aviation antisubmarine warfare technician, advanced electronics field	AXAE
Aviation maintenance administrationman	AZ
Boiler technician	BT
Boiler technician, advanced technical field	BTAT
Builder	BU
Construction electrician	CE
Construction mechanic	CM
Cryptologic technician (administration branch)	CTA
Cryptologic technician (interpretive branch)	CTI
Cryptologic technician (maintenance branch)	CTAE
Cryptologic technician (communications branch)	CTO
Cryptologic technician (collection branch)	CTR
Cryptologic technician (technical branch)	CTT
Disbursing clerk	DK
Data processing technician	DP
Data systems technician, advanced electronics field	DSAE
Dental technician	DT
Engineering aid	EA
Electrician's mate	EM
Electrician's mate, advanced technical field	EMAT
Electrician's mate, nuclear field	EMNF
Engineman	EN
Engineman, advanced technical field	ENAT
Equipment operator	EO
Electronics technician	ET
Electronics technician, advanced electronics field	ETAE

Table A-1 (Continued)

Rating Title	Abbreviation
Electronics technician, nuclear field	ETNF
Electronics warfare technician	EW
Electronics warfare technician, advanced electronics field	EWAE
Fire control technician	FT
Fire control technician, advanced electronics field	FTAE
Gunner's mate	GM
Gunner's mate (technician)	GMT
Hospital corpsman	HM
Hospital corpsman, advanced technical field	HMAT
Hull maintenance technician	HT
Hull maintenance technician, advanced technical field	HTAT
Interior communications electrician	IC
Interior communications electrician, advanced technical field	ICAT
Interior communications electrician, nuclear field	ICNF
Instrumentman	IM
Intelligence specialist	IS
Journalist	JO
Molder	ML
Machinist's mate	MM
Machinist's mate, nuclear field	MMNF
Mineman	MN
Machinery repairman	MR
Mess management specialist	MS
Opticalman	OM
Operations specialist	OS
Ocean systems technician	OT
Postal clerk	PC
POLARIS electronics technician, advanced electronics field	PEAE
Photographer's mate	PH
Patternmaker (includes MLCM)	PM
Personnelman	PN
Aircrew survival equipmentman	PR
Quartermaster	QM
Radioman	RM
Radioman, advanced technical field	RMAT
Ship's serviceman	SH
Storekeeper	SK
Signalman	SM
Sonar technician	ST
Sonar technician, advanced electronics field	STAE
Steelworker	SW
Tradevman	TD
Torpedoman's mate	TM
Utilitiesman	UT
Yeoman	YN

APPENDIX B

DECISION INDEX (DI) MEANS FOR JULY 1977 DATA SET

Table B-1

Decision Index (DI) Means For July 1977 Data Set
(N = 3,516)

Rating	DI Mean	Rating	DI Mean
AB	5243.	EWAE	4767.
AC	4969.	FT	4581.
AD	5233.	FTAE	4604.
AE	4647.	GM	5243.
AG	4727.	GMT	4946.
AK	4942.	HM	5171.
AM	5213.	HMAT	4660.
AO	5001.	HT	5148.
AQ	5166.	HTAT	4777.
AQAE	5117.	IC	5191.
AS	4904.	ICAT	4803.
AT	4337.	ICNF	4985.
ATAE	4364.	IM	4679.
AW	4458.	IS	4629.
AX	4545.	JO	4217.
AXAE	4521.	ML	4847.
AZ	4603.	MM	5368.
BT	5280.	MMNF	4878.
BTAT	4958.	MN	4827.
BU	4934.	MR	4940.
CE	5048.	MS	5167.
CM	5013.	OM	4379.
CTA	4729.	OS	5271.
CTI	4909.	OT	4750.
CTAE	4952.	PC	5231.
CTO	4901.	PEAE	4658.
CTR	5098.	PH	4985.
CTT	5069.	PM	4904.
DK	5107.	PN	5000.
DP	4960.	PR	5287.
DSAE	4429.	OM	4998.
DT	4994.	RM	5238.
EA	4484.	RMAT	5254.
EM	5119.	SH	5089.
EMAT	4664.	SK	5130.
EMNF	4759.	SM	5140.
EN	5062.	ST	4837.
ENAT	4662.	STAE	4821.
EO	5063.	SW	5033.
ET	4755.	TD	4590.
ETAE	4776.	TM	5004.
ETNF	4860.	UT	4961.
EW	4814.	YN	4939.

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